

# NASA ADVISORY COUNCIL

## Planetary Protection Subcommittee

May 20-21, 2014

NASA Headquarters  
Washington, D.C.

### MEETING MINUTES

---

Eugene Levy, Chair

---

Gale Allen, Executive Secretary

*Report prepared by Joan M. Zimmermann  
Zantech IT, Inc.*

Table of Contents

Introduction	3
PPO Update and Review	3
MSL Lessons Learned	5
InSight Status	8
Planetary Science and Mars Program Update	10
Contamination Limits for Planetary	
Life Detection	12
Mars Landing Site Selection Process	14
ESA 2018 Landing Site Selection	15
Mars 2020 Project Status	15
Public Comment	16
Discussion	16
Ethics Briefing	17
Discussion	17
Science Mission Directorate and Planetary	
Protection	17
Update on Special Regions Parameters	19
Status of Phobos/Demos Materials	21
Outer Solar System Special Regions:	
Enceladus and Beyond	22
JAXA Sample Return Working Group	23
Public Comment	24
Discussion	25

Appendix A- Attendees	
Appendix B- Membership roster	
Appendix C- Presentations	
Appendix D- Agenda	

May 20, 2014

### Introduction

The Executive Secretary of the Planetary Protection Subcommittee (PPS), Dr. Gale Allen, made preparatory announcements. Dr. Eugene Levy, PPS Chair, opened the meeting and noted there would be a heavy focus on Mars exploration, as it has become a timely and important issue. Introductions were made around the meeting room.

### Planetary Protection Office Update and Review

Dr. Catharine Conley, Planetary Protection Officer (PPO) for NASA, briefly described the broad base of experience in the PPS, and reviewed the purpose of Planetary Protection (PP) and the policy, as it applies to all missions. Understanding the origins of the universe, Solar System, and life all have relevance to PP, which seeks to study the origin of life without contaminating terrestrial life and the Earth's biosphere, and without contaminating other bodies in the Solar System. Research has shown that there are organisms that can exist in extreme conditions, and PP continues to identify and characterize objects that are potentially harmful to Earth. The PPO is governed by NASA Policy Document (NPD) 8020.7G, the National Research Council (NRC), the Committee on Outer Space Research (COSPAR), NASA Policy Requirements (NPR) 8020.12D, and the recently issued NASA Policy Instruction (NPI), NASA Policy on Planetary Protection Requirements for Human Extraterrestrial Missions, which has been signed by the Associate Administrators (AAs) of both Science Mission Directorate (SMD) and the Human Exploration and Operations Mission Directorate (HEOMD).

Elements of PP extend to other agencies beyond NASA. Article IX of the Outer Space Treaty requests advice from the U.N.'s International Council of Science (ICSU), which functions in parallel to the NRC in the US. The international structure is intended to be very transparent. NASA receives the policy and ensures compliance with policy, and converts these into requirements, as advised by external experts such as PPS. At some point, PP aspects will have to be raised above the NASA level to evaluate sample return from Mars, possibly even for the Mars 2020 mission currently in development.

The PPO also encompasses an independent verification function that helps to provide reporting to the NRC and the International Committee on Space Research. Coordination is carried out among NASA, State Department, Office of Science and Technology Policy (OSTP), Centers for Disease Control (CDC), US Department of Agriculture (USDA), Department of Homeland Security (DHS), Federal Aviation Administration (FAA), and the Department of Energy (DOE), to name just a few agencies. NASA also holds a Letter of Agreement with the European Space Agency (ESA). Planetary Protection within NASA is governed by the Offices of International and Interagency Relations (OIIR), General Counsel, Chief Engineer, Chief Technologist, Chief Scientist, and Health and Medical Officer, as well as the Office of

Safety and Mission Assurance (OSMA), SMD, HEOMD, and the Space Technology Mission Directorate (STMD). The PPS provides expert advice to NASA on PP, reviews mission activities, considers issues that fall below the international level of interest, provides guidance on program direction and implementation of PP requirements, and also serves as a mechanism for interagency coordination within the US government and internationally: PPS has *ex officio* membership from a range of US government organizations. PPS has historically progressed by consensus.

Recent recommendations from the PPS include a call to develop a document for human extraterrestrial missions at a level corresponding to the current COSPAR policy; this NPI is now complete, and next steps are in work. Responding to PPS expressions of concern on PPO staffing, research and support, as well as to observations on Mars program planning, and a presentation by Japan Aerospace Exploration Agency (JAXA) about a proposed Hayabusa-2 mission, there are now 2 additional detailees in the PPO to help support an uptick in PP activity. In November 2012, the PPS issued no formal recommendations, but did express concern regarding PP as carried out in the Mars Science Laboratory (MSL/Curiosity Rover) mission. In April 2013, PPS made recommendations to include the PPO early in the mission design process, as well as in the ongoing progress. In November 2013, the NAC Science Committee received a Lessons Learned briefing on MSL (MSL LL Report), and made a recommendation that went to the NASA Advisory Council (NAC). The NAC subsequently recommended a change in the PPO reporting line, to move the PPO out of the mission directorates to ensure independence of function. NASA concurred in part with this recommendation, but felt that formal reporting should remain within SMD for the time being. This situation will be evaluated as activities progress, and rationales will be revisited as SMD and HEOMD continue to collaborate.

Ongoing recent actions within PPO have included a response to the MSL LL report, acknowledging PP issues that have been raised within SMD and NASA as a whole, revising documentation, ensuring appropriate requirements flowdown on the Mars seismic mission, InSight; expanding PP training options, improving cross-directorate coordination, exploring opportunities for interaction with OSMA, developing a PP Operating Plan, and working to ensure incorporation of best practices and process improvements. A question was raised as to the role of OSMA in planetary protection.. The mission's Project Manager (PM) holds the responsibility for PP, but OSMA provides independent oversight of the PM. Orbital debris, for instance, is under the aegis of OSMA. A PPS member questioned whether OSMA should have a more direct role?

A PP research solicitation is currently being planned in the ROSES 2014 call, representing a slight increase in the PP budget. Programmatic needs are still being assessed. The total PPO budget was estimated at roughly \$2.5M in FY2013/14. External activities for PP have been included in the HR 3312 markup, addressing PP for human missions, and thereby initiating interactions with OIIR, engendering multiple interviews and media articles, as well as a panel discussion on PP at the

recent Humans 2 Mars Summit meeting in Washington, D. C.

Current and upcoming missions with relevance to PP include Cassini mission termination plans, which will entail a de-orbit into Saturn to protect the moon Enceladus. The mission is currently the subject of a Senior Review, which will need to address the requirement to ensure PP compliance over the rest of the mission. The InSight Mars mission has just passed its Critical Design Review (CDR); refinement of PP requirements for the Mars 2020 mission is under way; and work is in progress on the Europa Clipper mission's PP technology development, which has potential synergy with broader Planetary Science Division (PSD) implementation efforts.

### MSL Lessons Learned

Mr. Mark Saunders, Study Lead for the Mars Science Laboratory Lessons Learned report (MSL LL), presented findings and recommendations from this OCE-chartered effort. First conceived in June 2009, at an Agency Program Management Council (APMC), the Agency chose to fund an effort to understand the cost growth associated with MSL, but delayed a definitive study until MSL project personnel were not preoccupied with landing the spacecraft on Mars. It's a month prior to launch, MSL's PP categorization was abruptly changed from IV-c to IV-a, thus as a subgroup of concern, the MSL LL team was asked to examine aspects of how PP had been handled during mission development. Consequently, the MSL LL team included two PP experts on its panel. The team looked at everything associated with the mission, conducting extensive interviews and examining all available documentation. While the team acknowledges that MSL has been doing an astounding job, it did find numerous lessons to be learned, which can be applied to future missions in development.

MSL was originally conceived as a small technology demonstration in the early 2000s. When the Science Definition Team (SDT) report finally emerged, however, MSL had become a major science mission, with a payload of 8-10 instruments, and big changes in mass and volume. NASA struggled to get the mission into the box of the initial estimate of \$750M. The budget quickly inflated to \$1.4B, but the mission repeatedly failed its required milestone reviews, and had to de-scope considerably to reach \$1.4B. The Agency processes were loose, and the processes used to evaluate the mission scope were flawed. The budget soon grew to \$1.65B, and then to \$1.85B, by the time of System Integration Review (SIR). The announcement of a two-year launch delay was made 8 months after this assessment. At a re-baseline review required by Congress to extend the development by 2 years, the budget was \$2.5B.

The LL report notes that during its period of development, there were 5 different SMD AAs, two Administrators, large fluctuations in the budget, and much stress on the Mars Exploration Program (MEP) to keep the budget down. At the same time, Headquarters staff had been reduced by 50%, hurting the Agency's ability to oversee missions. MSL was a flagship mission by any definition, but the Agency did

not know it at the time of its conception. The MSL LL team believes that the Agency could have known that the scope and budget were mismatched. The question the LL study addresses is: Why didn't we know? Essentially, the study concluded that underestimating the cost of the mission led to underestimation of all other aspects of the mission; i.e. schedule, funding of technology development, and the appropriate length of certain mission phases (phase B, for instance which is normally up to 18 months long, was only 6 months for MSL). The study issued 7 findings and 3 recommendations, addressing the inadequacy of mission oversight and the lack of independent reviews.

Finding 1 –NASA has an historical culture of underestimation, which needs to be changed, and can be rectified by non-advocate Cost Assessment and Technology Evaluation (CATE) reviews.

Finding 2- The MSL project did not satisfactorily complete its formulation phase. (Mr. Saunders noted that the Agency has since made productive changes in this area).

Finding 3- Project management must improve its reporting processes, always maintain adequate margins, and adjust its management processes to more clearly present the status of a mission at a given time.

Finding 4- Management and oversight were inadequate for MSL at both the Headquarters (HQ) and Jet Propulsion Laboratory (JPL) levels, both of which were distracted by priority changes and understaffed to do the work. There should be a minimum of one Program Executive at HQ for a Flagship mission, as well as a Mission Manager. JPL should update its policy and practices accordingly.

Finding 5- Independent reviews (IRs) failed to identify the aggregate impact of individual issues on the system-level design, thus the Agency should strengthen the IR process.

Finding 7- NASA and Centers should follow documented policy and remain aware of and incorporate best practices.

Mr. Saunders addressed Finding 6 separately, as it dealt specifically with PP. This finding stated that PP as a discipline suffers from a lack of effective Systems Engineering (SE) and management practice. In the past, PP requirements were issued through a letter, which allowed requirements to be treated outside standard SE verification and flowdown processes. Dr. Rummel commented that when this process started out, the practices were not under the same rubrics as they are now. Mr. Saunders argued that PP requirements should be properly presented as NASA-defined Level 1 requirements. Ms. Sarah Gavit, a member of the MSL LL team, noted that PP requirements are treated differently if they are not presented as Level 1 requirements. Dr. Rummel countered that sometimes the Level 1 requirements don't come up until the mission knows where it is going and how it will get there.

The MSL LL report states that PP requirements were not written in a clear, concise, verifiable manner, making verification and validation (V&V) difficult, and which led to such last-minute problems as the issue of drill bit covers. The process of writing requirements can benefit from an engineering perspective. Dr. Rummel felt that a categorization letter must be matched with a plan that the project writes, as well as requirements flowdown; the important part is to get the overall requirements written into the mission plan, a chicken-and-egg dilemma. Dr. Mary Voytek commented that it seems like there are multiple decision points, such as site selection, that tend to precipitate critical decisions/requirements, and which need to be part of the process. Mr. Saunders responded that requirements for sterilization are clear, and that a mission determines the PP category up front; this can be the requirement, period.

Mr. Saunders briefly discussed the drill bit and wheel issues that affected MSL just prior to launch, adding that poor communication led to misunderstandings. MSL did, and Mars 2020 will, struggle with recontamination issues. Avoiding recontamination “as much as possible” is not a requirement. There is confusion across organizations as to who does what, how, and when, when it comes to PP. This line of communication should be strengthened. Importantly, the list of responsibilities of the PPO is not well served by the staffing level; it is not possible to carry all of these responsibilities out with such a small staff. The LL report also highlighted the need for the PPO to be out of conflict with the Planetary Science Division (PSD), which is the rationale behind the recommendation for placing the PPO elsewhere in the organization

The LL report specifically recommends that PP requirements be issued as Level 1s, so that they can be flowed down into the project, which can then do the work to fulfill them. Furthermore, NPD 8020.12 should be fixed in order to address recontamination issues. Dr. Rummel commented that HQ approval ends at the requirements level, and also at the point where implementation occurs. In the PP plan, there was not an explicit requirement as to how the wheels would be treated. Ms. Gavit noted that this is why requirements do not belong in plans-when buried in plans, engineers do not pay attention to them. Mr. Perry Stabekis commented that he absolutely agreed with the recommendation to put SE discipline into the requirements flowdown; it will make the verification process much simpler. Dr. Robert Lindberg agreed as well, adding that the traditional process of PP has operated in parallel with the SMA process, but on a separate path. He felt that the PP community would be well served by embracing the process used for all other requirements, as plans are implemented to meet requirements, and verification processes will ensure that requirements are met, thereby allowing a set of checks and balances to occur.

Mr. Saunders further delineated Finding 6, adding that SMD should put PP into its handbook, ought to expand training in PP, while ensuring that SMD and PPO should

have the right staffing levels. The PPO should also be supplied with an engineer to help write requirements.

MSL LL report recommendations on Mars 2020:

- SMD should implement recommendations of MSL LL.
- Fill the MEP Program Director position immediately
- Ensure that the Mars 2020 mission stays within the \$1.7B box- don't force the project to fail.
- Understand that if Mars 2020 is to be the first of 3 sample return missions, an adequate SE staff must be put in place.

Mr. Saunders summarized the report's takeaway messages as follows:

- Do a better job at understanding scope complexity and risk of directed missions (NASA already does this well with competed missions)
- Improve the independent review process so that it reveals the actual status of a project- it is not a replacement for oversight, but it needs to be done
- Formulation must be funded properly in order to understand future cost and scheduling needs of a mission.
- NASA must improve its implementation of Lessons Learned.

### InSight Status

Dr. Nick Benardini presented a status on the Mars InSight seismic mission, which recently passed its Critical Design Review (CDR), while distilling MSL LL at the "trench level." InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) is a Discovery-class mission, using Phoenix heritage for its lander concept and managed by JPL and Lockheed Martin. The projected launch date is in March 2016. The spacecraft will fly on an Atlas V vehicle with a 4-meter fairing, and will be the first PP mission flown out of Vandenberg Air Force Base (VAFB). InSight includes no life detection capability and is categorized as PP category IVa. Mission objectives are to understand the formation and evolution of terrestrial planets, and study the core and thermal state of the planet's interior, via a mole, termed the Heat Flow and Physical Properties Package (HP3), which will be provided by Germany. The mole is designed to penetrate 5 meters below the Mars surface, where it will take a series of thermal conductivity measurements to understand the thermal properties of the subsurface. A broadband seismometer (SEIS) will be used to measure seismic waves. A 23-day launch window opens on 4 March 2016. InSight will use an Entry Descent and Landing (EDL) technology that is essentially identical to that used for Phoenix; i.e. hypersonic chute, and radar detection from the base of the lander.

The InSight payload includes the Rotation and Interior Structure Experiment (RISE), a small deep-space transponder; as well as the SEIS instrument, a windshield, tether, and electronics box. PP is a global effort, which will be distributed among different

suppliers. There will be a lot of hardware to manage from the PP sense in the Assembly, Testing, Launch and Operations (ATLO) flow. The mission is designed to function over a 67-sol instrument deployment period, when it will have both SEIS and HP3 deployed to the surface. The landing site will be equatorial (3N to 5N), taking advantage of latitude for solar power. The “most flat boring place on Mars” will make PP easier, and will increase the probability of a safe landing and successful deployment of instruments. Twenty landing ellipses were recently downselected to four. A downselect to two sites will take place in late Summer/Fall 2014. A Landing Site Selection PPO review will take place in October 2015 after extensive use of HiRise imagery to identify appropriate sites with broken regolith.

Standard bioburden requirements for InSight include the use of an isolated cleanroom environment, organic inventory and probability of impact calculations. Additional project requirements include average internal bioburden of 1000 spores per meter squared. The mole will be designed to be unpowered and to cease operations immediately if the tether breaks. There shall be no ice at the landing site, and local conditions shall not generate a thin liquid that could transport a 50nm particle. Compliance with planetary protection is a Level I requirement; all PP requirements have been captured into the (Level 2) L2 Project System Requirement Document (the first project to capture all PP requirements into a Dynamic Object Oriented Requirements V&V tool.) All L2 and L3 are under Project Change Control Board Management. The project is also adopting new heat microbial reduction specifications that provide implementation options, and is changing to a more means-based mathematical treatment to calculate bioburden, similar to what the Viking mission employed, also taking into account the efficiencies of sampling tools.

The general implementation approach will use heat microbial reduction for cables/MLI; and isopropyl alcohol (IPA) cleaning. The Phoenix (PHX) implementation approach is the baseline for InSight. The Total bioburden, written as an L2 requirement, is  $5 \times 10^5$  spores. This total bioburden has been allocated by the project to the individual elements - allocated as 32k for PHX landed hardware, 32k for the parachute, etc.) 160k is held in project reserves. The landing site is not a special region as defined by PP, and the mole will be operating in such a way as to keep the heat down. It is thought that magnesium sulfate minerals are the most likely to dehydrate, and thermal models are continuing to undergo validation. The launch vehicle upper stage impact on Mars is calculated to be less than  $1.0 \times 10^{-4}$  for 50 years after launch. An approved NASA PPO methodology is being prepared for documentation. The project has developed a “Stoplight” laboratory monitoring system, which allows for real-time monitoring for evaluating bioburdens, and can be managed within the laboratory environment. Improvements have been undertaken in light of the MSL LL report; e.g., the project has adopted a SE approach for requirements flowdown. There is now a PP Equipment Implementation List, which is a one-stop Excel spreadsheet for PP implementation approach and bioburden cleaning regimens; PPO inclusion during Preliminary Design Review (PDR) and CDR subsystem and system level reviews; and involvement of the PPO early in the project for launch phase, including launch pad walkdowns. Foreign payload

management will be required to write an institutional PP Payload Implementation Plan. There is flowdown of PP requirements to L4 payloads; and adenosine triphosphate (ATP) assays will be required prior to delivery at ATLO. There has been effective and continuing communication with the PPO and designees, and the project is having quarterly meetings.

Project staff are interacting with VAFB, having had 4 visits to the base thus far, where PP training has been established. Thus far the schedule looks great. ATLO starts in November 2014, and the spacecraft will be shipped to VAFB in December 2015.

#### Planetary Science and Mars Program Update

Dr. James Green, Director of Planetary Science Division (PSD), briefed PPS on the status of division activities. Many mission and outreach events have occurred over the last year and a half. PSD launched the Mars aeronomy mission, MAVEN; observed the comet ISON with many assets; and is working with the Japanese space agency JAXA on EXCEED-Hubble Space Telescope observations of Io. The MSL Curiosity rover continues its traverse to Mount Sharp, and August 2014 will mark the two-year anniversary of MSL on Mars. Rosetta continues to approach its target comet. The comet Siding Spring will encounter Mars in October 2014, where Mars assets will be able to provide measurements and imagery during the flyby. Instrument selection for the Mars 2020 mission is expected to take place in June/July. The FY14 budget for PSD, which was well above the President's Budget Request, included a healthy Research and Analysis (R&A) allocation, \$40M for the Near-Earth Object (NEO) program, healthy funding for New Frontiers and the Discovery programs, \$65M for the Mars 2020 mission, and \$159M for the Outer Planets (including \$80M in study funds for the Europa Clipper mission concept).

The proposed FY15 budget includes additional SMD funding: \$15M for competed Education and Public Outreach (EPO) activities, and \$50M for the government-wide Opportunity, Growth, and Security Initiative (OGSI). The House recently approved the FY15 Commerce-Justice-Science appropriations bill, which includes \$302M for Mars exploration, and funds to get Discovery on a 24-month cadence. The Senate is working on this bill this week, so there is potentially good news for SMD for 2015.

A draft Discovery AO is anticipated by the end of May, with another AO following in September 2014. Advanced Stirling Radioisotope Generator (ASRG) technology is being brought in-house at Glenn Research Center (GRC), in anticipation of future use. PSD retains some Multi-mission Radioisotope Thermoelectric Generators (MMRTGs), and is still in the process of re-starting domestic plutonium <sup>238</sup> (Pu) production. However it will not be possible to use an MMRTG on the next Discovery mission due to the need to address some repairs at the Department of Energy (DOE). The launch readiness date for the Discovery mission is no later than December 2021, thus Dr. Green felt it would be possible to get Pu production moving well in time for the Mars 2020 mission, which is baselining an MMRTG.

A Senior Review for extended missions has just issued guidelines, and panels are starting. Results will be announced in June for Cassini, Lunar Reconnaissance Orbiter (LRO) the Mars Exploration Rover Opportunity, Mars Express, Mars Odyssey, Mars Reconnaissance Orbiter (MRO) and MSL.

The Mars 2020 mission held a site selection meeting June 14-16. PSD is working with HEO for an *in-situ* resource utilization (ISRU) experiment, and is reviewing some proposals for this.

PSD is currently planning for observations of the Siding Spring comet at Mars. This comet will fly through the ecliptic in front of Mars. It is thought that its coma will blanket Mars on the comet's closest approach on 19 October. Curiosity and Opportunity will be at the dawn and dusk sides of the planet and will be able to examine cometary dust. HST and NEO-WISE, Swift, and Spitzer have observed it. The comet will be 130,000 km from Mars at its closest approach.

Dr. Green provided the latest status of the Europa Clipper mission concept. The Decadal Survey has twice recommended Europa as a high science priority. Mission objectives are to study Europa's ocean, ice shell, global composition and chemistry, surface features and geology, the space environment, and to determine potential landing sites. A Jupiter Europa Orbiter was undertaken as the original concept, but at \$4.7B was deemed too expensive. The National Research Council (NRC) recommended that NASA undertake an effort to find a less expensive mission, and studies were undertaken to consider orbiter, multiple fly-by, and lander concepts. The Europa Clipper, multiple fly-by spacecraft in Jupiter orbit, has since been determined to provide significant science return as per the Decadal Survey's recommendations. PSD is moving forward to refine the Clipper concept, particularly since the discovery of a plume on Europa, recently observed by HST. A Request for Information (RFI) solicitation has been issued. As directed by Congress, NASA will release a competitive Announcement of Opportunity (AO) for the Europa Clipper's risk reduction phase (Phase A), and consider a two-year cruise phase with the Space Launch System (SLS; currently under development at NASA) versus a 7-year cruise with a gravity slingshot approach. Solar as well as nuclear power options are being considered. There are some design issues to be addressed as well, as the spacecraft will have to survive inner solar system conditions during a slingshot approach. SLS will open up the Outer Planets for the next decade. The SLS is a multibillion-dollar HEO investment that is being designed to provide heavy lift capacity for missions beyond low-Earth orbit.

For FY14 and beyond, PSD will lose \$5.6M/year with respect to Education and Public Outreach (EPO) activities. FY14 appropriation language states that FY14 will be a transition year as EPO is assessed. EPO's goal is to contribute to scientific literacy of the US public. The President's Budget Request had included \$15M for PSD in support of Science, Technology, Engineering and Mathematics (STEM) activities; a

new plan will be released before 1 October. Dr. Boston expressed concern that the community would be able to respond to EPO proposals in a meaningful way.

The R&A program has undergone restructuring; ROSES13 had 20 calls, and ROSES14 had 19 calls. ROSES14 will be funded out of FY15 funding.

Asked about the Asteroid Redirect Mission (ARM), Dr. Green explained that ARM is not a PSD mission; PSD's only role is to identify the object to be examined. Two concepts that are currently being considered are a sample return mission, or a redirect mission. ARM will most likely be a HEO or a Space Technology mission, in roughly 2018. Dr. Rummel commented that ARM sounded a little undefined for a 2018 mission. Dr. Green noted that the mission concept can provide technology feed-forward for such things as ion propulsion. Responding to a question from Dr. Penny Boston, Dr. Green noted that MSL can detect any organics that sift through the atmosphere from the passing of the Siding Spring comet. Dr. Peter Doran asked if the Europa mission concept would help to define the cost of a lander. Dr. Green responded that the Clipper will need a high-resolution camera and a radiation monitor. Europa is a relatively large body, and Jupiter sweeps out the radiation environment every 11 hours, thus the landing site will probably be survivable during those periods. The approach will be further defined in the next Decadal Survey. There may be a draft Europa AO, possibly in the form of a Stand-Alone Mission of Opportunity Notice (SALMON).

#### Contamination Limits for Planetary Life Detection

Dr. Conley discussed the NASA criteria for a sample-caching effort associated with the Mars 2020 mission. The 2020 Science Definition Team (SDT) states that 3 attributes are necessary for a returnable cache: scientific value, compliance with PP requirements, and the cache is returnable in an engineering sense. Compliance with PP must be met at policy levels (COSPAR and NASA PP NPD/NPRs), and on both mission legs, outbound and return. Under COSPAR policy, all sample return missions are life detection missions. The outbound must be category IVb and the return leg category V restricted Earth return. The first concern is to avoid false-positive and false-negative indications in a life or hazard determination protocol, in order to protect the Earth from potential martian biohazards, the second is to protect Mars samples from Earth contamination.

Category IVb is concerned with ensuring high efficacy for life detection experiments. Category V for the return leg will require that a program of life detection and biohazard testing or proven sterilization process to be undertaken. This is an absolute precondition for the controlled distribution of any portion of the sample. A PP organic contamination requirement will be necessary in order to accurately identify and characterize the level of risk associated with potential contaminating sources and the probability of contamination upon return. The mission must also reliably execute the life detection and biohazard protocol. To reach a conclusion as to how to carry out these criteria, HQ/MEP convened an Organic Contamination Panel, recommendations from which will be reviewed by PPS. The National Research Council (NRC) has convened a meeting of experts that will take place the week of 26

May, followed by a joint PP-Mars Science Organic Contamination Requirement Distillation meeting, the results of which will be passed on to the Mars 2020 mission planners. A critical goal is to have a single PP/Science cleanliness requirement, available at the System Requirements Review (SRR) minus 1.5 months.

Dr. Gerhard Kminek presented a briefing derived from ESA studies on Organic Contamination Control for the ExoMars 2018 mission. The studies resulted in a report by a Contamination Control tiger team that examined requirements previously applied to flight systems, verification processes available at present, and further requirements that would be necessary for a life detection mission. The team was led by the prime contractor for ExoMars and included members of the mission's science team. The major goal of the report was to establish an acceptable threshold of terrestrial organic contamination per gram of sample delivered to the instrument (50 ng range for organics of biological sources, but up to the microgram range for tested engineering sources). The threshold has since been refined to include figures on monomers of Kapton, Mylar, and polytetrafluoroethylene (PTFE), fluorinated technical lubricants, and "any other organic compound."

PP requirements apply to the subsystems involved in the acquisition, delivery, and analysis of martian samples for life detection. The process is designed to protect sensitive surfaces based on segregation (sealed sample path) and overpressure. This process is still in work. Requirements include an aseptic ISO 3, ISO AMC-9 cleaning and assembly environment for sample path; cleaning approach is to clean at lowest (parts) level, start bake-outs at the lowest integration level (sub-assemblies), and perform sterilization at the highest integration level possible. Cleaning is based on a sequence of solvent cleaning (sonication), bake-out, carbon dioxide snow cleaning, and a hot-gas purge. Pre-launch verification of the primary requirements can be accomplished with a combination of direct flight hardware testing, and testing of a qualification model using blanks processed during the entire sample chain, before and after environmental tests. It is important to establish cleaning procedures, including bake-out, early in the hardware design phase. Asked if it were intrinsically impossible or too costly to perform end-to-end tests, Dr. Kminek responded that two models are necessary (for ExoMars): processing samples through the whole flight system would distribute too much particulate matter throughout the system; so part of the verification is on the qualification model (good qualification model), and part of the verification is on the flight model. There are also prescribed cleanliness procedures for the hardware, and it is up to the contractor to decide how clean the hardware is to meet the overall requirement (i.e. acceptable terrestrial contamination of the samples delivered for analysis).

Dr. Conley reported briefly on NASA's Organic Contamination Panel (OCP), whose goal is to establish contamination thresholds that have to do with terrestrial organic compounds that could get into samples taken at Mars (from the hardware that collects samples at Mars). The OCP issued four findings:

Finding 1- detection and characterization of indigenous organic compounds is of fundamental and critical importance to the searches for ancient and extant life in martian samples. It must be taken into account that one cannot culture most terrestrial microbes, as well as the fact that there are many organic molecules that cannot be readily synthesized by abiotic chemistry.

Finding 2- it must be accepted that it will not be possible to reduce all organic contaminants to non-detectable levels by all analytical techniques; there is an inherent tradeoff between sensitivity and breadth of detection. In addition, certain contaminants are worse than others.

Finding 3- reducing specific contaminants (that interfere with compounds of scientific interest) is as important as reducing the total contamination burden.

Finding 4- control and categorization (C&C) are complementary and required. C&C has practical limits (cost and technical). The characteristics of all contaminants is important, and their variability is a key aspect of characterization; thus meeting contamination limits is necessary but not sufficient. Knowledge of all actual contaminants is necessary to increase confidence in results.

The proposed Mars 2020 rover is based on the MSL platform. Science instrumentation is to-be-determined but will likely be carried out with an eye to astrobiology, and will have a capability to drill, seal, and cache core samples. For 2020, direct contact, particle transport, and volatile organic compound (VOC) transport are the three means by which contaminants can be introduced. The cache concept, proposed to hold 500 g, is still being refined by science assessment groups.

#### Mars Landing Site Selection Process: 2020 and ESA/ExoMars

Dr. John Grant briefed PPS on the outcome of the First Mars 2020 Landing Site Workshop, which brought together broad expertise in an effort to identify a scientifically interesting site that also allows a successful landing. The site must meet all engineering and PP requirements, as well as the objectives determined by the SDT. Assembling the sample cache (to include igneous rocks) has become a big driver for landing site selection. Dr. Levy commented that this driver underscores the tension between life detection and geological objectives. Mr. Wallace added that the search for “ancient” life should also be emphasized.

Data sets for the 2020 mission have greatly expanded since the time of the Viking era. Multiple calls (including a previous 2018 mission concept) for future landing sites have resulted in 55 general candidates, and an additional 9 identified expressly for 2020. Well over 550 images have been taken from HiRISE through February 2014; there are very good visible and spectrographic data for future sites. Thus far the site selection groups have been avoiding special regions, given the more extensive ice mapping that has been done on Mars in recent years.

Workshop deliverables include the provision of a guide for future imaging of the sites; consideration of whether candidate sites are “land-on” or “go-to;” and

consideration of the value of Entry, Descent and Landing (EDL) enhancements. No sites are to be eliminated unless they violate basic engineering criteria. An opportunity for new sites to be considered will take place at the second workshop, which will be held in Summer/Fall 2015, depending on the need for further imaging. There are 28 initial sites, ranked by priority. There has been a lot of interest in NE Syrtis (MSL could not traverse to this site- it has a diversity of samples spread out over martian history). Others include the Nili Fossae Trough (too high for MSL), Nili Fossae Carbonates, and Jezero Crater Delta. The Holden Crater contains layered sediments, a possible alluvial fan, and impact megabreccia. The McLaughlin crater has the potential for having held upwelling water in the remote past, consistent with a groundwater-fed lake. Gusev Crater has had some interesting advocates, including researchers who worked on the Spirit MER. Another advocate was 8<sup>th</sup> grader Alex Longo, who sent in a two-page abstract, and who will be speaking again at the next workshop.

### 2018 ExoMars Landing Site Selection

Dr. Kminek reviewed results of an ESA landing site selection workshop for the ExoMars 2018. A new partner for 2018 is Roscosmos. There 4 general criteria for the site: it must be scientifically compelling, safe for landing and surface operations, and must meet PP constraints. From a scientific point of view, the site must be older than 3.6 billion years, must show some aqueous activity and sedimentary rock outcrops distributed over the landing site. The site must have little dust coverage. The rover range will be just a few kilometers. ESA issued a call for Letters of Application for Membership in November 2013, and a kickoff of the Landing Site Selection Working Group (LSSWG) in December 2013. Proposals were received in February, and the first workshop was held in March of this year. Dr. Kminek reviewed the membership of the LSSWG, which contains broad representation from PP, industry, astrobiology, etc. Eight sites were initially proposed between latitudes 5S and 25N. After being put to a vote, Mawrth Vallis and Oxia Planum (ancient massive clay formations), and Hypanis Vallis and Oxia Palus (sedimentary delta and meandering river, respectively), received the highest rankings. The highest priority at this point is to submit imaging requests to confirm conditions at each site. More data will be required from existing assets at Mars. Ideally, one would like to look for recurring slope lineae (RSL). The working group is holding weekly telecons to consolidate site rankings. The mission PDR is due to be held this Summer, and the hope is to go to PDR with no more than 4 sites, and with other backup sites clearly ranked. The 4 sites will then go through a more detailed engineering assessment.

### Mars 2020 Project Status

Mr. Wallace gave a briefing on the status of the Mars 2020 mission, the objectives of which are to explore an astrobiologically relevant ancient environment on Mars to decipher geological processes and history; demonstrate significant progress toward sample return; and carry a HEOMD/STP *in-situ* demonstration payload. Final objectives are to be determined through the payload selection. Launch is scheduled to take place in July/August 2020. Mission parameters include the re-use of SkyCrane as an EDL technique, and a one-Mars-year surface mission. The mission

began phase A in November 2013. AO evaluations are proceeding on schedule, while the mission buys down heritage risk, puts key vendors on contract, and builds flight hardware. The instrument selection process is currently under way and will be finalized in July. A Sample Quality Workshop was held on 16 March, and a Flight System Baseline Workshop was held 29-30 April. A Systems Readiness Review SRR will be held in October of this year. Roughly 90-95% of the spacecraft has identical requirements to MSL. There is also \$200M of residual hardware. The project has been provided with substantial FY13/14 funds to buy down risk. There will be newly selected instruments and a sampling system/cache on the rover. MSL heritage equipment includes residual star scanners, propellant tanks, aeroshell, flight spare heat shield, MSL EDL Instrument (MEDLI; embedded in the thermal protection system), radio systems, inertial measurement units (IMUs), and flight-spare descent stage hardware among other things.

Payloads selection is scheduled for July. The sampling system is a new development with the potential for some MSL inheritance, which will support arm-mounted *in-situ* instruments selected via AO, and which will provide abrading/brushing capabilities for contact and remote-sensing payloads, and enable core acquisition and caching. There are multiple sampling system architectures under study, including one bit per sample, and sample tubes inside re-useable bits. Many caching components are metallic and can withstand heating to 500°C to get maximum cleanliness. Dr. Rummel commented that instruments near the coring arm/end of the turret seem to be problematic with respect to contamination.

The 2020 project has been aggressively working PP and contamination/control issues for more than a year, and has established a monthly management meeting with PPO, with a significant early focus on the sample caching system. The goal is to achieve unprecedented pre-launch cleanliness that approaches Adventitious Carbon physical limits. To this end, the project supports establishment of an independent Organic Contamination Panel (OCP) to be formed by the Mars Program with input from Planetary Protection. In addition, application of MSL Lessons Learned is being actively pursued, as the project works with PP senior leadership and applies disciplined SE practices to requirements flowdown and validation, separating implementation and requirements to increase project ownership and accountability, which will preserve the exceptional forward contamination levels achieved on MSL/Curiosity (60 to 70k spores, as measured against the 300k requirement). The cost of the mission will be established at Key Decision Point-C (KDP-C), in about a year and a half.

The project has addressed the unexpected wheel degradation experienced by Curiosity (thought to have been caused by an unusually sharp rock field). A tiger team is up and running to gain a better understanding of the new environment; it will probably be necessary to change the tread thickness and pattern to avoid the same problem. The biggest PP challenge thus far is controlling organic contamination levels; i.e. getting cleanliness levels that support the use of sensitive

instruments on Earth. Avoiding recontamination failure modes will be challenging, thus the threats need to be clearly understood and mitigated.

#### Public comment session

Ms. Marcia Smith asked if the MSL LL study was available to the public. Dr. Allen noted that both the Executive Summary and related documentation have not yet been released to the public.

#### Discussion

Dr. Lindberg commended the MSL LL team for its work, and was pleased to see that the InSight mission had adopted the Lessons Learned. However, he felt that NASA had not yet codified these lessons so as to become standard practice and recommended that they be codified in policy documentation. Dr. Lisa May noted that the Agency had been briefed on MSL LL, and has created a Working Group to develop responses and an action plan, which will subsequently be briefed to upper management within a matter of weeks.

In response to a question, Dr. Allen addressed some aspects of the NAC re-organization. Dr. Allen noted that the NAC now has an EPO representative, and that the individual subcommittees can now communicate directly to the directorate AAs, instead of first reporting up to the NAC. The NAC has also formed a task force to address Big Data, for a limited period of time. Dr. Rummel cautioned that there must be more active PP guidance for the Europa Clipper AO and the ARM AOs, particularly in the interactions with the human crew and vehicle. The potential hazards (e.g., cyanide, microbes) of an asteroid sample return must be more clearly understood. Dr. Conley noted that as part of the mission planning process, the characteristics of the returned object would be ascertained. Dr. Allen took an action to put an ARM briefing on the agenda of the next PPS meeting. Dr. Kminek commented that one of the questions is how much radiation is available to sterilize the surface of the asteroid; the exposure is orders of magnitudes less when one is considering a core sample.

#### May 21, 2014

##### Ethics Briefing

PPS members received a requisite annual Ethics Briefing.

#### Discussion

The PPS wrapped up issues arising from the previous day. Dr. Levy felt it would be timely to respond to the MSL LL report upon its public release. Dr. Lindberg raised the ongoing concerns regarding PP and private space enterprises. While the issues are challenging, he agreed that PPS does not have jurisdiction in these matters but does maintain an interest in them, therefore the issue needs to stay on the long-term agenda of the subcommittee. Dr. Rummel felt that it would be useful to stay engaged with the Office of the General Counsel (OGC), Department of State, and the Department of Transportation (DOT) on PP for private space endeavors. Dr. Vigdor Teplitz commented that the State Department is well aware of issues via the

minutes of PPS meeting, and observed that each agency is cautious about sharing its thoughts when they are clearly incomplete; he offered to transmit specific thoughts to State. It was also recommended that a representative from the Office of Science and Technology Policy be included.

#### SMD and Planetary Protection

Dr. Chuck Gay, Deputy Associate Administrator for SMD, addressed PPS and made himself available for questions and discussions on the status of PP in the Directorate. Dr. Rummel mentioned that PP seems to run into cost tensions when a mission attempts to ensure that PP requirements get written into Level 1 (L1) requirements, and looked forward to seeing these requirements adopted in a more standardized fashion. Dr. Gay noted that SMD AA John Grunsfeld signs off on these requirements, and that SMD continues to work with Dr. Conley for both guidance and concurrence, and that directorate-wide, SMD is beginning to look at how it allocates, validates and maintains the chain of custody for L1 requirements. Dr. Rummel suggested that SMD also link and integrate its science measurements with PP, leveraging a leadership area for SMD. The continuing interaction with HEOMD will also benefit from a formal pathway for implementing and linking L1 requirements. Mars Sample Return will require a lot of planning, including the construction of a Sample Receiving Facility, preparation of Environmental Impact Statements, etc. Dr. Betsy Pugel, a recent detailee to the PPO, noted that Dr. George Tahu had successfully brought PP considerations into Mars 2020 early in the planning stage. Dr. Green noted that there is now an international group which is considering sample return, as well as a number of international facilities that might be receptive. Siting issues will remain complex and challenging, however.

Dr. Levy asked whether SMD had the will to institutionalize and codify PP requirements on missions, as recommended by the MSL LL report, a move which will likely require some bolstering of resources in the PPO. Dr. Gay responded that SMD is always trying to do the right thing, and to this end he meets with Dr. Conley at least twice a month, while remaining concerned about her workload, and ameliorating this recently with a new PP detailee. SMD continues to actively seek support for Dr. Conley, and continues to look at the budget for this purpose. Dr. Rummel noted that planned missions to Europa and Enceladus, as well as Mars Sample Return, are all good reasons for stepping up the effort.

Dr. Levy mentioned that PPS has been discussing non-governmental initiatives that can raise PP issues, while lacking a clear sense of the nation's obligations under the Outer Space Treaty (OST), and how they can be enforced. The best PPS can say that a conversation is valuable. Dr. Gay responded that he has discussed this situation with Dr. Conley, and socialization has started, while looking to the OGC for advice on how to remain compliant with Treaty obligations; NASA is not a regulatory agency in this respect, but still must capture the issues and make recommendations. Dr. Gay felt it would be important to have regular interactions with PPS so as to hear the ongoing conversation, rather than waiting for the issuance of a paper: dialogue is where SMD can get a real benefit. Dr. Rummel noted that PPS has representation from other

parts of government and international space agencies, and that the Environmental Protection Agency (EPA) and the Department of Homeland Security (DHS) also have some convergence. NASA technologies in dealing with biohazards have generated interest in Congress for recent, relevant events.

Dr. Levy asked Dr. Gay to provide a rationale for the SMD response to a NAC recommendation for moving the location of the PPO in the organization. Dr. Gay noted that SMD was not dismissive of the recommendation, having discussed it at some length. SMD is not opposed to following the recommendation sometime in the future. SMD has begun to make good progress in PP in terms of Dr. Conley working with HEO, and integration of PP and PSD staff. Having gained some momentum, SMD was reluctant to perturb a good thing. Dr. Levy agreed that it has been gratifying to see steady improvement in this area. Dr. Teplitz commented that the Asteroid Retrieval Mission (ARM) has not yet been assigned. Dr. Gay pointed out that SMD's role in the ARM remains one of identification and characterization of potential targets. Dr. Allen added that ARM is still in pre-phase A, and there is as yet no budget assigned to it; the ARM will be assigned to a directorate in FY16, most likely HEOMD.

#### Update on Special Regions Parameters

Dr. Rummel provided an update on the activities of the Mars Special Regions Science Analysis Group (SR-SAG), whose preliminary report is available at the Mars Exploration Program Analysis Group (MEPAG) website ([mepag.nasa.gov](http://mepag.nasa.gov)). Special regions are regions where terrestrial organisms are likely to replicate, etc., and are of interest to PP so as to avoid introduction of microbes that might possibly persist and reproduce on the martian surface. Mineral deliquescence was a particular issue addressed by the Science Analysis Group (SAG), as were special and uncertain locations on Mars, water-related sources on Mars, and the potential for accessing water-related sources. The concept of Mars special regions is based on what is understood about natural conditions, conditions required for terrestrial microbes, and induced environments (i.e. heat from RTGs). Perchlorate, found on Mars, is an energy source, but it is also a heavy oxidant. Modern Mars does have energy sources for microbes, and the amount of oxygen present on Mars has been shown to support some aerobic organisms on Earth. After considering microbial passenger lists for outbound missions, the SAG found no evidence that any terrestrial microbe can be ruled out as a potential passenger on spacecraft.

Dr. Rummel reviewed the recommended parameters for use in identifying special regions, such as temperature, water activity, the potential for thin film water, vapor-phase water, etc. The low-temperature limit has been lowered from -13°C to -18°C. Cellular metabolic activity has not been demonstrated below -33°C, however some compounds can decrease the low-temperature limit of growth. A review of the literature since the SAG's previous report shows no evidence of either cell division or metabolism below a water activity of 0.6. With respect to Mars atmospheric composition and pressure, most Earth bacteria tested failed to grow below 25 mbar;

however an increasing subset of bacteria have been shown to grow at pressures as low as 7 mbar.

Determining the continuity/heterogeneity of microscale conditions on Mars over time and space will be a major challenge; further research will be needed to bridge the gap between orbital data and microbiology. Microenvironments of known relevance to terrestrial microbes have been characterized, as well as exploration-induced microenvironments. A literature search on the limits of microbial use of vapor-phase water did not reveal definitive evidence that any terrestrial organisms can utilize ambient humidity alone. Matric-induced reductions (dessication) are more inhibitory to microbial cell division than solute-induced reductions. Thin films that are present on grains in shallow subsurface sites are probably not habitable by terrestrial microbes. However Mars conditions are close to the triple point of water and temporary excursions are allowable to condensation, particularly at the cusp of light and dark. Mars environments with potentially naturally occurring special regions include Recurring Slope Lineae (RSLs), caves, and some slope streaks. The Special Regions SAG (SR-SAG) has established a context and forecast for a predictable 500-year protection period on Mars; it is expected that low latitudes will continue to dry out slowly.

RSLs seem to be active when peak temperatures are at 250°K, according to THEMIS data (actual peak surface temperatures are probably higher); due to the orbital phasing of the spacecraft carrying THEMIS this observation leads to the recommendation that RSLs be treated as special regions. For some gullies, it is likely that the motive force is subliming CO<sub>2</sub> disrupting material that moves down slopes. Gullies active at CO<sub>2</sub> frostpoint are at the northern and southern latitudes. Gullies associated with residual ice have the potential for producing liquid water in the next 500 years. Large fresh craters are also a potential thermal source. The SR-SAG has been unable to rule out the possibility of near-surface water (MARSIS and SHARAD may not be able to provide detectability for groundwater). THEMIS has not located any thermal zones (hot spots) on Mars. Subsurface conditions have been characterized at the Phoenix (PHX) site; at certain times of night, the relative humidity is high enough to support microbes, but during the day, the humidity is too low to support microbial life. Essentially, Mars can be warm or wet, but generally not at the same time. Natural deliquescence on Mars is currently thought to be outside the boundaries of the conditions required for reproduction of terrestrial organisms.

Spacecraft-induced special regions, such as those that might occur during an EDL-phase spacecraft breakup, have also been considered in multiple failure scenarios. High-speed impact of an isotopic heat source could induce the formation of a special region. There is a good probability that tropical mountain glaciers on Mars contain residual ice. Spacecraft-induced deliquescence on Mars may be triggered by presence of a nearby spacecraft, or by the actions of a spacecraft. A preliminary map of features with relevance to interpreting special regions has been constructed.

The SR-SAG has framed some recommendations in light of the discovery of RSLs and has constructed a map of confirmed and partially confirmed RSLs, and has also considered some proposed missions to gullies. Evaluating possible special regions induced by future missions must be considered as well. There are significant knowledge gaps in the current understanding of the synergy of multiple factors on microbial growth (temperature and water), extreme parameters, water activity, lower temperature limits for life, hydrated minerals, the story of ice at the PHX landing site, and continued atmospheric observations (such as that of water snow falling on the ground at night at the PHX site).

Human exploration at Mars raises the possibility of the spread of terrestrial biological contamination that could impact human life support systems. Water resources on Mars (polar caps and high-latitude ice) may not be useful in terms of accessibility; CO<sub>2</sub> outgassing could also prove to be a safety issue. Mid-latitude sites are probably the best suited for human exploration, but nuclear power would be required for extended visits. In the equatorial region, ice deposits are pretty deep, with limited accessibility. Water/oxygen *in-situ* resource utilization (ISRU) is limited by the amount of energy required to run CO<sub>2</sub> electrolysis systems, regolith baking ovens, and water vapor condensers. The presence of dust in the martian atmosphere would be a further hindrance to operating such systems. Hydrated minerals are available, but it would take extreme effort to get water out of them. Perchlorates can be used for fuel, but they are noxious to humans. In terms of radiation environments, galactic cosmic radiation is relatively low on the surface. Radiation shielding could be carried out through the use of water barriers or by sheltering in caves. An ice igloo would also be an excellent radiation shielding device.

There are several ways to limit the contamination of special regions by human activities, one of which is the use of clean robotic rovers in special regions. Dr. Boston commented that it would be tremendously useful to uncover knowledge gaps, particularly in the timing sequence of organismal needs for survival/reproduction; these should emerge as research foci. Dr. Rummel added that a new strategy would be necessary to study things like clean approaches to RSLs, as well as the convergence of special regions and human resources as a “nice package,” as long as humans don’t contaminate what they are trying to study.

#### Status of Phobos/Deimos material- Restricted or Not?

Dr. Kminek presented an overview of PP considerations for the Mars moon, Phobos. Both ESA and Russia have been considering launch opportunities to Phobos from 2024 onwards; ESA in particular has been exploring a mission intended to obtain 100 g of sample from Phobos, to be returned to the Woomera Test Range in Australia. Parallel and competitive industrial studies are in progress. Possible cooperation with Roscosmos has been considered, and some ESA in-house activities have been initiated. All the ingredients are in place to prepare an implementation proposal to the ESA Council in 2016. There has been some concern over the transfer of material from Mars to Phobos. Different models predict that there is martian material on Phobos in the parts-per-million (ppm) range, with major transfers

possibly having taken place within the last 3 million years (Mojave Crater). Given these assumptions, one would expect about 250 ppm Mars material in a Phobos sample. Much of the material could be considered to be biologically inactive according to sterilization estimations (heat and ionizing radiation), but this needs to be verified by tests and reviewed.

Initial testing has been carried at the Fraunhofer Institute (Ernst Mach Institute) to simulate what happens to a projectile that has been ejected from Mars and impacts regolith; the goal of preliminary testing was to demonstrate an ability to manufacture basaltic projectiles accelerated to 5 km/s, and recover them from a low-density target with pore space similar to martian materials. Feasibility was demonstrated. The ESA Planetary Protection Working Group (EPPWG) convened a workshop to complete a list of modeling and test parameters, and then distilled these parameters into a Statement of Work for a contract. A two-phase 14-month test approach was adopted in an effort to obtain statistical, meaningful numbers. A kickoff is planned for July 2014. Phase I is scheduled for completion in February 2015, and Phase II in October 2015, with a review of results planned in late 2015. Dr. Kminek reported that proposals have been received, and expected the testing to occur in a timely manner. A meeting participant noted that HEOMD is considering a human mission concept to Phobos. Dr. Conley offered PPS the opportunity to obtain more information on these human exploration concepts at its next meeting.

#### Outer Solar System Sample Return: Enceladus and Beyond

Dr. Ariel Anbar provided an overview of some generic issues affecting a class of Outer Solar System (OSS) sample-return missions. Cassini has discovered bioessential elements such as water, energy and organic molecules on Enceladus, which are indications of habitability. Enceladus is thought to harbor a subsurface ocean, apparently habitable, with potential hydrothermal systems conducive for prebiotic chemistry. The next logical steps are to search for presence of biomarkers and prebiotic chemistry at the body; accessibility of its recently discovered plumes makes this mission feasible. The Stardust mission through the tail of comet Wild 2 is a good concept for an Enceladus sample return mission. A cometary amino acid, glycine, e.g., has been found in Stardust samples. Terrestrial laboratories and techniques can provide the necessary high-mass resolution (which currently exceeds that of flight-qualified instruments), highlighting the need for sample return.

Dr. Anbar presented a mission concept termed Life Investigation for Enceladus (LIFE), essentially a Stardust-like flight through an Enceladus plume, which would be developed as a Discovery-class mission. The spacecraft would carry one mass spectrometer (legacy from a previous mission), and partner with JAXA to leverage the Hayabusa experience. Beyond the LIFE mission, one might regard it as a generic architecture for investigating Europa, Ceres, Titan atmosphere, and even Mars. There are however key concerns with regard to PP: contamination of the target, the cleanliness of the sampling system, containment during re-entry and landing, and containment during receiving and analysis.

The sampling system will be based on an aerogel such as that used to capture particles from comet Wild 2, which has a high surface area (low-density silica). PP requires “breaking the chain” on the route of sample return. It is very hard to validate the escape of viral-sized particles, due to their inherent “stickiness;” more studies are needed in this area. Some argue that antioxidant defenses have evolved in organisms through horizontal gene transfer from organisms that live in oxidizing environments, and have attempted to make a case that organisms living in the oxygen-less atmosphere of Enceladus could not evolve such a defense, and thus would not be of concern for PP. It was pointed out that when radiation meets water on Enceladus, it would quite likely result in evolved oxygen.

Potential roads to a LIFE mission would require that a PP working group be formed, coordinating with the Institute of Space and Astronautical Science (ISAS) Working Group in Japan, so as to carry out an end-to-end design and cost study of such a mission; the PP research and development effort should be focused on sample return issues. Mr. Perry Stabekis commented that before the Viking era, it took a number of years of funding at a high level in the late 60s and early 70s, in academia, industry and laboratories. The effort went into Viking with the expectation that the craft would not be the last such craft. A considerable investment must be made, and that single investment should not go to a single mission; there should be a widespread technology investment to ensure future missions and an acceptable amortization of funding.

Dr. Green noted that Enceladus is on the list of bodies being considered in the new Planetary Decadal Survey, indicating it is time for NASA to turn its attention to a mission. There is already some infrastructure to be leveraged, such as the curation facility at the Johnson Space Center (JSC); sample return is here to stay. Dr. Kmínek mentioned that there are curation and containment facilities included in the European Commission 2020 element.

#### JAXA Sample Return Working Group

Dr. Hajime Yano presented a JAXA report, via Webex, on missions-in-development Hayabusa-2 and Procyon, and a newly formed International Collaboration Sample Return Working Group (ICSRWG). Hayabusa-2 is scheduled to launch in late 2014, arrive at Asteroid 1999JU in July 2018, and return to Earth in 2020. Hayabusa-2 will make multiple surface sampling attempts using a kinetic impactor, including an attempt to collect freshly excavated subsurface material. The COSPAR PP Panel concluded that Hayabusa-2 was considered an outbound category II mission, and an inbound category V. Dr. Yano reviewed probability analyses for Hayabusa-2.

The Procyon mission, a microsatellite piggyback on Hayabusa-2, is being designed to do a flyby of Asteroid J2000EC; depending on the situation, JAXA will eliminate the candidate NEAs if the spacecraft has too large a probability of impact on Mars in the trajectory.

The ICRSWG is in the process of considering future plans by destination: the SELENE-2 mission to the Moon, Mars 2020, and Solar Power Sail Destiny (targeted to small bodies). Future directions include deep space round trips and small body sample returns using Hayabusa heritage methods. There is also an effort to build up technology readiness levels (TRLs) of solar sail technology for traverse to the Outer Planets. Dr. Yano briefly reviewed the structure of the JAXA Safety Review Board, which includes a JAXA PP Safety Review Board.

An ISAS International Collaboration Sample Return WG was established in 2013 to develop touchdown sampling systems, flyby sampling systems, containment systems, etc. The Japan Agency for Marine Earth Science and Technology (JAMSTEC) is a related organization devoted to ground development and calibration experiment facilities. The WG has also performed ice impact experiments on aerogel, reviewed the characteristics of both Hayabusa-1 and -2 sample containers, including a new container that uses a noble gas ventilation interface at the bottom of the canister. Hayabusa-2 will employ a direct Earth re-entry capsule system similar to that of Hayabusa-1. New ablator materials will be needed for Hayabusa-2 due to higher re-entry velocity. Ground operations for the returned capsule recovery, will include a CT of the capsule before opening. Initial considerations for a sample analysis and curation facility include a JAMSTEC Biosafety Sample Handling Operation and Facility, a waterborne facility that has routinely carried out subsurface hydrothermal microorganism sample returns. This facility is being offered as a small Biosafety Level-4 (BSL-4) lab to be used for any particular mission.

The new WG hopes to have active collaboration with NASA through a counterpart team to develop key enabling technologies for sample return from Outer Planets regions, and to solve PP challenges. The subcommittee briefly discussed the logic behind using a ship for sample return processing. Dr. Yano noted that the primary reason for considering a ship is that there are no land-based operational BSL-4 facilities in Japan. Furthermore the ship can operate in open international waters, and recover a sample via splashdown operations. The ship would be under Japanese registry, but a regulatory framework for a ship-based containment facility has yet to be determined. Hayabusa-type sample handling would not require an extensive laboratory, just a semi-robotic vacuum chamber plus a glove-box. The PPS further discussed the pros and cons of shipboard handling and agreed that further discussion and analysis would be prudent.

#### Public comment period

No comments were noted.

#### Discussion

Dr. Levy identified no formal recommendations, and felt it would be useful to revert to the use of a letter to the SMD AA to call attention to some issues, including subcommittee reaction to the improved PP implemented by InSight; the placement and the reporting line of PPO; and the value of cross-cutting technology and facility

development for sample return, as well as ESA/JAXA efforts along the same lines. Dr. Lindberg added that PPS would continue to monitor the placement of the PPO. Dr. Allen pointed out that the MSL LL report had made this same point.

At the conclusion of the meeting, Dr. Levy acknowledged Perry Stabekis's imminent retirement and expressed gratitude for his immense contributions to the discipline of Planetary Protection, and to the subcommittee. Dr. Levy adjourned the meeting at 3:50pm.

## Appendix A Attendees

### Planetary Protection Subcommittee Members

**Eugene Levy**, *Chair Planetary Protection Subcommittee*, Rice University  
Penny Boston, New Mexico Tech  
Kelvin Coleman, Federal Aviation Administration  
Catharine Conley, *Planetary Protection Officer*, NASA HQ  
Peter Doran, University of Illinois, Chicago  
Joanne Gabrynowicz, University of Mississippi  
Gerhard Kminek, European Space Agency  
Robert Lindberg, *PPS Vice Chair*, University of Virginia  
Claudia Mickelson, MIT  
John Rummel, East Carolina University  
Michel Viso, CMES, France  
Gale Allen, *Executive Secretary PPS*, NASA HQ

### NASA Attendees

Barbara Adde, NASA HQ  
Carlton Allen, NASA HQ  
J. Nick Bernardini, NASA JPL  
Mark Fries, NASA HQ  
Charles Gay, NASA SMD, HQ  
Ann Delo, NASA HQ  
Deirdre Healey, OSMA, NASA HQ  
James Johnson, NASA HQ/JSC  
Melissa Jones, NASA JPL  
Ying Lin, NASA JPL  
Lisa May, NASA HQ  
Betsy Pugel, NASA GSFC  
Margaret Race, NASA HQ  
Mitch Schulte, NASA HQ  
Gerald Smith, NASA HQ  
James Spry, NASA JPL  
Perry Stabekis, NASA  
George Tahu, NASA HQ  
Shannon Valley, NASA HQ  
Mary Voytek, NASA HQ  
Matt Wallace, NASA JPL

Non-NASA Attendees

Ariel Anbar, ASU

Abby Azari, IDA

Charles Fletcher, Consultant

Sarah Gavit, Consultant

Dale Griffin, USGS

Bhavya Lal, Science and Technology Policy Institute

Allen Li, House Science Committee

James Lochner, USRA

David Millman, Unaffiliated

Mark Saunders, Consultant

Yukio Shimizu, JAXA

Heather Smith, AIMS

Marcia Smith, Space Policy

Peter Tsou, Sample Exploration Systems

Elda Tsou, St John's University

Hajime Yano, JAXA

Ana Wilson, Zantech IT

Joan Zimmermann, Zantech IT

## Appendix B Committee Membership

**Eugene H. Levy (Chair)**

Provost/Professor of Physics and Astronomy  
Rice University

**Robert Lindberg (Vice Chair)**

Department of Mechanical and Aerospace Engineering  
University of Virginia

**Gale Allen, Executive Secretary**

Deputy Chief Scientist  
NASA Headquarters

**Catharine Conley, Planetary Protection Officer**

Planetary Sciences Division  
Science Mission Directorate  
NASA Headquarters

**Penny Boston**

Department of Earth and Environmental Science  
New Mexico Tech

**Colleen Cavanaugh**

Biological Laboratories  
Harvard University

**Peter Doran**

Associate Professor, Earth and Environmental Sciences  
University of Illinois at Chicago

**Joanne Irene Gabrynowicz**

University of Mississippi School of Law

**Claudia Mickelson**

BSP Deputy Director, Office of Environment, Health & Safety  
MIT

**Jon D. Miller**

Joseph A. Hannah Professor of Integrative Studies

Michigan State University

John D. Rummel  
Department of Biology  
East Carolina University

Andrew Steele  
Geophysical Laboratory  
Carnegie Institution of Washington

**Agency Representatives:**

Kelvin Coleman  
Federal Aviation Administration  
Washington, D.C.

Dale Griffin  
Environmental/Public Health Microbiologist  
United States Geological Survey

Victoria Hipkin  
Program Scientist, Planetary Exploration  
Canadian Space Agency

Gerhard Kminek  
European Space Agency

Gerhard H. Schwehm, SCI-OS  
Head of Solar System Science Operations Division  
ESAC

Vigdor Teplitz  
Department of State  
Washington, D.C.

Michel Viso  
Astro/Exobiologie  
Astrobiology  
Vétérinaire/DVM  
CNES/DSP/EU

**Subcommittee Administrative Support:**

Ms. Ann Delo  
Administration Officer  
NASA Headquarters

## Appendix C Presentations

1. Planetary Protection at NASA- Overview and Status; *Catharine Conley*
2. Mars Science Laboratory Lessons Learned Report; *Mark Saunders*
3. InSight Planetary Protection Overview; *J. Nick Bernardini*
4. Process for Developing Organic Contamination Limits Associated with Mars Sample Caching and Return; *Catharine Conley, Betsy Pugel*
5. First Mars 2020 Landing Site Selection Workshop; *John Grant, Matt Golombek*
6. 2018 Landing Site Selection; *Gerhard Kminek*
7. Mars 2020 Project Status; *Matt Wallace*
8. MEPAG Special Regions Science Analysis- Group 2 Preliminary Report; *John Rummel*
9. Status of Planetary Protection Approach for Phobos; *Gerhard Kminek*
10. Outer Solar System Sample Return- Enceladus and Beyond; *Ariel Anbar*
11. JAXA Report on Hayabusa-2, Procyon and the International Collaboration Sample Return Working Group; *Hajime Yano*

## Appendix D

Planetary Protection Subcommittee Agenda  
NASA Headquarters  
300 E ST SW, Washington, DC  
May 20-21, 2014

### May 20, 2014 NASA HQ (Room 3D42)

WebEx link is <https://nasa.webex.com/> 997-873-342, password PSS@May2014

Dial in: 888-603-9625, Passcode: 4599

8:00 am	Welcome, Orientation, Introductions	G. Allen, HQ
8:05 am	Words from the Chair	E. Levy, Rice Univ.
8:15 am	Status of Planetary Protection at NASA: Issues and Status	C. Conley, HQ
9:00 am	MSL Lessons' Learned	M. Saunders
10:00 am	Break	
10:15 am	Status of InSight Project Compliance	N. Benardini, JPL
11:00 am	Planetary Science and Mars Program	J. Green, HQ
12:00 noon	Lunch	
1:15 pm	Contamination Limits for Planetary Life Detection	C. Conley/G. Kiminek
2:00 pm	Mars Landing Site Selection Process: 2020 and ESA/ExoMars	J. Grant/G. Kminek
2:45 pm	Discussion	E. Levy/G. Allen
3:00 pm	Mars 2020 status	M. Wallace, JPL
3:45 pm	Break	
4:00 pm	Discussion (public)	E. Levy/G. Allen
4:15 pm	Discussion	E. Levy/G. Allen
5:00 pm	Adjourn for the Day	

Planetary Protection Subcommittee Agenda  
NASA Headquarters  
300 E ST SW, Washington, DC  
May 20-21, 2014

**May 21, 2014 NASA HQ (Room 3D42)**

Webex link <https://nasa.webex.com/> 998-038-108, password is PSS@may2014.

Dial in: 888-603-9625, Passcode: 4599

8:30 am	Ethics Training	J. Reistrup, HQ
9:30 am	Break	
9:45 am	Overview of the Day	E. Levy/G. Allen
10:00 am	SMD and Planetary Protection	C. Gay, HQ
10:45 am	Update on Special Regions Parameters	J. Rummel, ECU
11:45 am	Lunch	
1:00 pm	Status of Phobos/Deimos material restricted or not?	C. Conley, HQ/ G. Kminek, ESA
1:30 pm	Outer Solar System Sample Return: Enceladus and Beyond	Ariel Anbar, ASU
2:00 pm	JAXA Sample Return Working Group	Hajime Yano, JAXA
2:30 pm	Discussion (public)	E. Levy/G. Allen
2:45 pm	Discussion/Findings/Recommendations	E. Levy/C. Conley
4:00 pm	Adjourn	